# PRIORITISATION OF AN IT BUDGET WITHIN A LOCAL AUTHORITY

## Abstract

This paper describes the prioritisation of an IT budget within a department of a local authority. The decision problem is cast as a simple multiattribute evaluation but from two perspectives. First, as an exercise in group decision making. Here the emphasis is on a shared process wherein the object is to obtain consensus. The use of an explicit evaluation framework and the ability to interact with the evaluation data in real time via a simple spreadsheet model were found to improve the decision making. Second, the prioritisation is made analytically. The motivation is to determine the degree to which the rankings are the result of the structural characteristics of the projects themselves rather than of the differences in importance attached to the achievement of the goals represented by the project attributes. Three methods are used: Monte Carlo simulation of ranks, cluster analysis based on attributes and an approach based on entropy maximisation. It is found that in the case studied the structure inherent in the data is high and so the results of the analyses are robust. Finally, a procedure is suggested for the appropriate use of these analyses via a facilitator to aid prioritisation decisions.

**Keywords:** group decision support, information systems, multi-objective, cluster analysis

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Prioritisation of candidates for expenditure from a fixed budget is a common task achieved by one of a number of different methods, from the quantitatively analytical to the more discursive. IT expenditure illustrates the difficulties involved and the different methods available[1,2,3,4], notably simple scoring systems. Performance against a number of criteria is assessed and a linear weighted sum of these measures provides an overall score for each candidate and so a priority ranking. Such simple methods are popular because of their very simplicity and transparency, characteristics which make them a useful decision aid for supporting group decisions, one of which is examined here: the prioritisation of an IT budget by the City of Edinburgh Council.

The paper is organised as follows: the prioritisation process as it occurred is described; reflection on this leads to a suggestion for a method which would, in retrospect, have been useful in facilitating the decision making process; characteristics of the problem and of the role of the proposed method are discussed.

## Background

A sum of money is available each year for expenditure on IT projects suggested by departments of the Council. The IT Department received written bids, including those from itself, and put them in an initial priority order. This list was sent back to the departments who then made written comments and representations and otherwise lobbied as necessary. This process was thought to be unsatisfactory because the bidding departments did not feel fully involved except via the mainly paper interactions required. The IT Department was also keen to make the system more consensual rather than being seen as, in the main, the imposer of a solution or, at best, arbiter between competing claimants. The particular prioritisation described below was of projects within the City Development Department which contained the divisions of Economic Development, Local Area Services, Planning and Transport and Communications.

It was decided that for 1997 representatives from all divisions would meet to decide funding priorities. It was subsequently decided also to attempt a form of multicriteria evaluation as a decision aiding device. The chairman of the meeting was enthusiastic to try this approach. Participants in the decision were aware that a somewhat different process was to be used but not, in detail, what it was to be. Each division prepared a list of projects for funding, as in the past.

## Agreeing criteria

A meeting was convened at which all divisions including the IT Department were represented. There were ten people in all. Tables were arranged in a square. A computer and linked projection equipment were provided.

To introduce the scoring system a demonstration was to be given of the basic ideas. It was to help in this that I had been asked by the chairman to attend as an external advisor. I was unknown to the others.

A brief presentation was given, emphasising the importance of deciding criteria, and that this was likely to be a non-trivial task, as would be the subsequent data collection. As a result attention turned to the evaluation process rather than the evaluation decision. It was quickly agreed that two meetings would be needed, this first to concentrate on agreeing a structure for evaluation and another for the actual prioritisation. In the interim data would be collected and reflection given on the structure of the evaluation proposed. Two- or multi-stage processes are common enough in such situations[5,6]. This agreement to have two meetings had the desired effect of directing attention to the process by which the decision might be made and away from the detail of the thirty four proposals which the representatives had brought. to be prioritised.

The members of the group had expected to argue a case rather than to think about the principles of evaluation. Thinking in some abstract fashion

is difficult and may be so difficult as not to yield useful results. To provoke views about the process pairs of projects were chosen at random and attempts made to choose the better. The reasons for the preferences were discussed and so a shared understanding reached of which criteria might be used and why. That all were involved in this discussion was, it was clear, greatly valued. The group was aware that the Council had explicit objectives which it had undertaken to promote in all its activities and it became clear that these were, at least, influencing the discussion. Increasingly reference was made to these objectives and it was agreed that it would both be simplest and would ensure coherence with other areas of choice were they to be adopted as the basis for this prioritisation. Here are the six criteria.

*1. Efficiency*. The money value of the cost savings likely to be achieved including the value of staff time saved. Measurement to be to the nearest £10k.

*2. Effectiveness*. The *improvement* in effectiveness to be achieved including not only the amount of improvement made but also the number of people benefiting from it. Scores were given according to the scheme shown in Table 1.

*3. External budget advantage*. The money value of the additional external income to be generated by the project over its whole life or over the first

five years of its life, whichever was the smaller. Measured to the nearest £10k.

*4. Departmental cohesion*. The number of *additional* departmental functions linked by the project. This was of particular concern to the council since it had recently been enlarged by amalgamation with other councils.

*5. Compliance with policy*. The improvement in policy compliance within four areas: City Strategies, City Development Strategies, moving forward policies and objectives, committee approved initiatives.The first two were the names of declared Council policy initiatives. Scores were using a scheme similar to that shown in Table 1, but with rows showing the number of policies affected: 0 to 3 or more.

*6. Compliance with statute etc.* The *improvement* in compliance with statutory and other obligations, such as parliamentary acts, statutory instruments, Health and Safety Regulations and Audit Commission requirements. The improvement in compliance was measured according to a six point scale: 0 for nil to 5 for high.

We were by now towards the end of the meeting. Many of the ideas were new to those involved and they did not have the data now needed for evaluation. Some of the definitions of impact (low, medium, high, etc.) were somewhat vague, but were left for discussion at the next meeting.

## Ranking

The second meeting was about two weeks later. The data which had been collected were agreed and criteria confirmed. To help in the interpretation of weights the measures of performance against each of the criteria were scaled from zero (worst) to five (best), thereby creating a measure of goal achievement, five representing complete achievement of the goal. The result is shown in Table 2.

To start the evaluation of weights it was decided that each member of the group (except me) should write their own ranking of criteria with 6 denoting the most important. The results are shown in Table 3. The sum of the ranks is shown in the penultimate line. It was agreed that *Budget* was the most important, that the attributes *Efficiency*, *Effectiveness* and *Policy* were equally important as were attributes *Cohesion* and *Statutory*, though at a lower level. The three groups of attributes were given weights $a$, $b$ and $c$, as shown in the last line of the table, with $a>b>c$. In discussing values for the weights the sums of the ranks were noted and it was decided that an exploratory start would be to set $a/b = b/c = 1.4$, this being an approximate summary of those sums of ranks as shown in Table 3. The requirement that the weights should sum to 1 gave $a$=0.24, $b$=0.17 and $c$=0.12.

While there was no real unhappiness about the resulting ranking some examination of sensitivity, and so robustness, was thought to be desirable. It was easy to test changes to weights and the projection of the spreadsheet meant that all members of the group could easily follow what was going on. This may sound a trivial point but that reassessments could be made and the results seen without a calculation break, as it were, was helpful in maintaining the momentum of useful discussion.

In a spirit of experimentation a ratio of $a/b = 0.7$ was tried and seen to have remarkably little effect. Other values of $a/b = 2$ and $a/b = 0.5$ also had little effect. (Throughout, $b/c$ remained at 1.4 since the top ranking was believed not to be affected by this ratio. The *post hoc* analyses described below retrospectively support this.) There was now some considerable confidence that a robust prioritisation had been made, the top 10 projects were the same in all cases. An evaluation with equal weights was also made. The rankings are shown in Table 4. The mean score obtained on these five evaluations is shown, as a percentage of the highest, in column *a* and the corresponding project numbers in column *b*. These are the rankings taken from the meeting.

The next five columns, *c* to *g*, show where the individual rankings differed from the summary. The differences are trivial, usually just a positional swap of one or two places (see also Table 5). This is reinforced by the rank correlations at the foot of each column (given for indicative

rather than inferential purposes). With alternative project evaluations for the allocation of a fixed budget what is important is the difference in the projects that would be selected should the first ten or twelve or whatever be chosen with different rankings. Figure 1(a) shows this relation for columns *f* and *b* ofTable 4. The horizontal axis shows how far down the rankings is considered, 1 for just the first scheme and 34 for all, and the vertical axis shows the number of candidates in common up to that point. The upper diagonal line shows the case of identical rankings and the lower shows when there is a difference of two schemes, if the top ten of both rankings have eight candidates in common, for example. The graph shows that no more than one scheme would be affected by using *f* instead of *b*, wherever the cut imposed by the budget limit was made.

At the end of the session all participants were happy to support the result, feeling that this process was an improvement on previous exercises. This was largely attributable to the involvement made possible via group decision[7]. It may well also have been that this cheerful confidence arose because of the demonstration that the decision was determined mostly by the data, on which all agreed and which could readily be defended to councillors and others, and not by potentially contentious weights.

## *Retrospective analyses*

The group had discovered a strong robustness. Perhaps some analysis before the second meeting demonstrating this would have been helpful in

providing both an appreciation of the characteristics of the selection problem and also a useful start to the second meeting; but the data were available only at that meeting. In addition the sense of joint ownership apparent as a result of participation was important, particularly in this divisional organisation. It was not just that there was a great deal of structure in the data but also that this structure was jointly discovered by those charged with making the decision. Nonetheless, some intermediate analysis may have been useful. In this section such exploratory analyses are described and retrospectively applied.

***Monte Carlo Simulation***

Uncertainty about a ranking is due, in some part, to uncertainty about the values taken by the weights. This effect may be modelled via simulation. Starting with the idea that all criteria are equally important suggests a uniform distribution with all weights set to 0.17. Initial uncertainty may be modelled with a rectangular distribution with limits range 0.005 and 0.35 (i.e. from about zero to about twice the uniform value). The simulated ranks are shown in Figure 2, ordered according to the mean simulated rank. The correspondence between this ranking and that from the meeting is extremely good so that, in this case, the outcome of the meeting could have been anticipated.

The robustness of the modelled rankings is shown by the box plots in Figure 2. Disregarding, for the present, the shading of the boxes, it can be seen that the inter-quartile estimates of rank do not exhibit much

uncertainty. The lines extending to the end of the range do indicate some volatility but, it may be supposed, this results from very non-uniform weight sets. This diagram gives a summary both of initial results and of robustness. It would provide a good stimulus for a discussion, though just presenting these results in lieu of group discussion would risk losing the ownership through participation already described; no trivial point. However, this analysis would have provided a prompt for the facilitators and could be offered to the group if judged useful. That discussion would be even better informed if there were to be some understanding of why those ranks obtain. Cluster analysis may help to do this.

***Cluster Analysis***

Clustering defines groups whose members are similar to each other and dissimilar to members of other groups: many methods are available[8,9,10]. Using an agglomerative algorithm with a Euclidean distance measure (section 4.2.4 of Everitt[8]) gives the dendrogram in Figure 3. Defining clusters by cutting the dendrogram at the level shown by the broken line, gives three clusters and two singletons, schemes 15 and 16. One of the clusters is tentatively subdivided at a lower level. The relation between cluster membership and rank is shown via the shading of the boxes in Figure 2.

Cluster A plus the singletons constitute the first five projects. The members of clusters B and C constitute nine of the next ten so that in sum these three clusters and the singletons account for fourteen of the top

fifteen projects (certainly sufficient for the budget available). The prioritising group could, as a result, be fairly confident that this ranking is the result of the characteristics of the candidate schemes and not just of the weights. This dual view, of preference and of structure, should give some assurance about the recommendations made and allay any feelings of dissatisfaction about the result.

The cluster profiles are shown in Figure 4. Each radial spoke in the chart represents an attribute and is scaled from a minimum of zero at the centre to a maximum of five at the furthermost point. The boundaries of the shaded areas show the mean scores.

The two clusters and two singleton at the head of the ranking achieved prominence in different ways. Cluster A is pretty good in all respects save contributing to statutory compliance. It is particularly strong in assisting with policy compliance. Cluster C, on the other hand, scores generally not so highly. It makes no contribution at all to the enhancement of the external budget but is effective in improving departmental cohesion. Cluster C is more concerned with improving the internal workings of the council. Of the singletons scheme 16 is particularly strong in its contribution to the external budget and promotion of efficiency and is not poor anywhere: it is unsurprising that it should be ranked first. Scheme 15 also makes a high budget contribution but is poor in promoting efficiency.

Clusters B and D are, as indicated by the dendrogram, similar: B being average against four of the six criteria and D poor in all respects. Cluster D contains twenty of the thirty four schemes and these are fated to form the tail of any ranking, unlikely to attract expenditure however they are judged.

Clusters have two uses. First, and primarily, to inform as to the structural basis of the ranking. Second, in the prioritisation it may be that focussing on just these stereotypes and expressing preferences between them rather than the thirty four candidates is cognitively more feasible and so offers a useful start for the process.

***Being noncommital***

An analysis preceding, and in preparation for, the second meeting would commonly be based on giving all weights the same value of 1/6. This is seen to be fair in that it does not discriminate between criteria and may be justified by an appeal to the principle of entropy maximisation. This approach was originally proposed for the evaluation of probabilities[11] but is also employed in the solution of multiattribute problems[12,13,14,15]. Entropy is a measure of the flatness of a distribution and it is the principle of the method that by choosing these flattest distributions one is being maximally noncommittal and thereby avoiding biased estimates. The enforced modesty of the method is particularly appealing when dealing with judgmental inputs. An arbitrary vector $Z$ has entropy

$$H(Z) = \ln(\sum z_i) - [\ \sum z_i \ln(z_i) / \sum z_i\ ]$$

If the sum of the elements is unity, as in the case of weights $W$, then

$$H(W) = -\sum w_i \ln(w_i)$$

Maximising $H(W)$, subject only to the constraints that the weights be non-negative and sum to 1.0 gives the uniform weight distribution. But with uniform weights a ranking between alternatives is induced, which may be seen as not a non-committal starting point. Alternatively, the entropy of the summary scores for candidates may be maximised. The scheme scores are $y_i = \sum w_j x_{ij}$ , where the $x_{ij}$ values are from Table 2. Choosing weights to maximise $H(Y)$ gives the most uniform set of scheme evaluations (though not uniform, with fewer weights than candidates). The results are shown in column *h* of Table 4. Maximising $H(Y)$ rather than $H(W)$ one is minimally discriminating between outcomes rather than between weights[15] since the object of the prioritisation is to choose between candidates rather than to model a preference structure *per se*. Projects which perform well, even when, as here, those performances have been made to be as uniform as possible, have some claim on our attention as being of worth.

Figure 1(b) shows the correspondence between the rankings obtained by maximising $H(Y)$ and maximising $H(W)$. The differences are not great.

## Discussion

### *Group Decision*

The budget allocation decision, even though routine, may be seen as a stage in the implementation of a strategy. Nutt[16,17,18] identifies four styles for implementation: by intervention, participation, persuasion and edict. The method used here is participatory, whereas previously it had been interventionist. The adoption of the group decision process was a clear recognition that it provided a better means for the involvement of the divisions within the Department. The role of the sponsor is important in Nutt's model and the shift to group decision places the IT Manager in the role of sponsor rather than, as previously, arbitrator. It might be argued that the adoption of the six objectives of the Council greatly reduced the freedom of action of the group to the choice of weights only rather than the choice of criteria. However, this adoption was itself a decision of the group and was not part of an imposed specification. Inasmuch as any large organisation has explicit policy objectives it is natural for them to be recognised.

Participative implementation usually recognises the need for a coming together of vested interests but with disinterested experts giving advice and providing some facilitation. In the present case I was placed in the role of technical advisor while the chairman was disinterested in that he was making no bids, though he was from the Development Department.

To an extent, therefore, there was the possibility that he was the agent of the sponsor with the task of an agent, selling a point of view, and in so doing moving the process from participation to persuasion. While the chairman did intervene to move things forward this appeared to be done neutrally, preserving the participative mode. Care was taken by both of us to focus on process rather than content thereby avoiding any feeling of de-skilling by the group[19].

Members of the group were chosen to represent their divisions with no consideration given to the requirements of succesful group work in terms either of decision making styles[20,21,22] or group size, although the number, eight, was about the size that has often been found to work well[19,23]. The group was homogeneous in the sense that all were professionals in a technical department so that the possibility of different interpretations of the prioritisation problem due to the different perspectives of managers and professionals[24] was avoided.

***Evaluation***

Evaluation problems are sometimes susceptible to quantitative approaches but, as has often been noted, formal rational models are not popular. van Wegen and de Hoog[25] give three conditions which may account for this in the evaluation of information systems: uncertainty about outcomes; uncertainty about goals; the impossibility of measuring all outcomes. Bannister and Remenyi[26] point out the prevalence of non-formal methods, noting that “expressions such as acts of faith or gut instinct are sometimes

euphemistically replaced by the term 'strategic insight' which really means the same thing." King and McAulay[27] note many cases where IT investments have been justified by individual belief, corporate image, the need to influence third parties and similar presumed imperatives, pointing out that in cases such as these it is unsurprising that evaluation is carried out in the high variety language of conversation and argument rather than the low level language of formal quantitative method[28]. The dichotomy between hard and soft analyses may be overstated[4], for any quantitative method must be used in a social context and then only to support a decision, not to supplant the decision makers. In these circumstances the use of a simple decision aid, a scoring system in this case, was of use.

***Scoring***

Scoring models are popular "because of their simplicity of formulation"[1] and have found application in IT evaluation[29,30]. This simplicity is not necessarily bought at the expense of inferior performance, with reports of correlations as high as ninety percent between the rank ordering produced by scoring and by more technically complex methods[31]. Much of the literature on scoring is concerned with the attribution of values to weights because of the view that "an improper selection of weights can radically alter the selected portfolio [of projects]"[32]. The selection problem examined here did not show that volatility, rather the opposite.

Such robust evaluations are desirable for as well as difficulties in deciding the method for weight valuation there is the other, probably less tractable,

problem the interaction between model and user. That users may have difficulty deciding the decision problems presented to them during an interaction due to their use of biased heuristics[33,34] and cognitive or information overload[35,36] is familiar both as a general proposition and in relation to multiattribute problems[37,38,39,40,41] and leads to the conclusion that "the pursuit of precise weights may be an illusion"[42]. The work described above recognises this primarily in its treatment of weights as being parameters about the values of which only uncertain, which is to say probabilistic, estimates may be possible, leading to consequential uncertainty about ranks and an emphasis on the robustness of recommendations made. Further, the criterion of being minimally discriminating between alternatives (rather than between weights) has as its object mitigation of the worst consequences of judgmental fallibility.

Weights may be seen either as expressions of preference for the attainment of one goal over another or merely as parameters in an optimisation problem. My initial belief was that the former presented difficulties, for what did it mean to say that one goal was twice as important as another? Decision makers decide and so preference information was in decisions, with weights just there to keep score, as it were, and to ensure consistent extrapolation from those decisions to other candidates. Consequently I tried to encourage the group to express preferences between candidates or in reduced bicriterial problems. But the group did not wish to do this, they much preferred to talk about weights because, I think, they saw the determination of weights as synonymous

with the determination of policy, which they perceived to be their task. Because of this focus on weights the sensitivity and simulation analyses were appropriate as ways of exploring robustness for they too focused on weights. In the event, the different weight sets did not have much effect on the ranking of candidates (Table 5 and Figure 1).

***Supporting group decision***

Different opinions within the group were initially articulated as different weight values and a trial consensus found by a simple aggregation. It may seem that this process is somewhat arbitrary but groups can easily and comprehensibly simply average weights and so get an agreed set of weights. Such models "are essentially models of policy, jointly formulated by multiple groups [*sic*] or individuals"[5]. Averaging may be of the preferences of individuals[6,30,43] or constituencies[44,45,46,47]. However the aggregation is made, simple scoring encourages consensus, the revelation of preferences and can cope with both quantitative and judgmental inputs[2].

Although computer packages have been found useful in supporting group decision[23] the extent to which software may be helpful is sometimes compromised by the very sophistication of the packages, for software embodies the designers' rational model of group decision and so forces a method that may be inappropriate[48]. The use of a simple scoring model and a projected spreadsheet provided an easily understood process with sufficient flexibility to accommodate what was at times a fairly informal

discussion. Neither should the value of the spreadsheet as familiar metaphor be underestimated.

The case described here supports the view of Philips and Philips[19] that "Computer models help to take the heat out of disagreements. The model allows participants to try different judgements without commitment, to see the results, and then to change their views" and that "computer-based tools, which are external to the group and not part of it, can provide the facilitator with a powerful means" of aiding group decision.

## Conclusion

As a result of the prioritisation and subsequent analyses a three-stage process may be proposed (Figure 5). The analyses to be made between the meetings are for the facilitator and not directly for the group so that the involvement of the group, the shared discovery of a solution, may be moderated according to the judgement of the facilitator. It is not the case that as the group is moving towards a solution that very solution, or one like it, should be produced as a rabbit from a hat. That may undermine the group and render unachievable that sense of commitment needed for successful implementation. And yet, if this is judged not to be a risk, the process may be hastened, if that is necessary, by the introduction of some of the analyses.

As provocations to a discussion of weight evaluation the group may consider the radar diagrams (Figure 4) and the relative merits of clusters. This achieves the twin objectives of complexity reduction and the anonymity provided by considering average candidates and so avoiding the importation of information irrelevant to the evaluation model at this stage.

Comparison of the ranks obtained using equal weights and nearly equal scheme evaluations (Figure 1(b)) convey robustness. These plus the simulation and any other analyses will be for the facilitator, to provide some picture of whether this problem is likely to be sensitive to weights or not.

It is to be hoped that the second meeting will be short. In the case described here meetings 2 and 3 were conflated. However, it may be prudent to allow for some debate at the second stage which may, in turn, lead to a restatement of the criteria to be used and so the collection of different data.

There are reservations which might be entertained about this proposal. First, the simple scoring rule is used because of its ubiquity and popularity with decision makers[49] but the interpretation of the meaning of weights was not as clear as perhaps it should have been given the different methods available[37,49]. In mitigation it may be pointed out that the

insensitivity of the results indicate that the effect is likely to have been slight but, nonetheless, in less robust cases more care should be exercised. Second, uncertainty about ranking was assumed to come only from uncertainty about weights and yet it is to be expected that there will also be uncertainty about the performance measures. The method described could be extended to take account of these, though necessarily at the cost of a more protracted analysis and presentation of results. Third, some measures, the ratings, were defined on an ordinal scale and have been taken as cardinal for the purpose of calculation. Though common practice this is a weakness, although the magnitude of the effect may not be great.

The proposed method offers a flexible support in the facilitation of a decision process. The motivation is to use the simplest formalism required to bring the benefits which arise from providing some structure while also, via the facilitator, anticipating some of the difficulties inherent in the problem.

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